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DESCRIPTION OF INVENTION

"IMPROVEMENTS IN OR RELATING TO AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTICS DATA DOWNLOAD TRANSMISSION SYSTEM"

THE PRESENT INVENTION is directed generally to an aircraft maintenance/diagnostics data transmission system and, more particularly, to an on-board cellular data transmission/reception system operable in conjunction with maintenance/diagnostics data transmission over public telephone networks and the Internet.

It is common for aircraft avionics and electronic engine control systems to require download of maintenance/diagnostic data for maintenance purposes. Presently, most aircraft utilized in passenger, freighter and business categories require some degree of diagnostic data download from one or more avionics and engine control equipment, such as an Electronic Engine Computer (EEC), Data Encryption Unit (DEU), Flight Management Computer (FMC), etc. These downloads are currently accomplished manually by connecting a download device to the aircraft, or using permanently installed maintenance/diagnostics terminals. The diagnostic information is transferred from the avionics equipment to storage media, such as floppy disks or CD-ROMs. Upon completion of the transfer from the avionics unit to the

storage media, the maintenance/diagnostic information is transferred to the maintenance centre of the airline for processing.

The current manual download includes the human as an active component of this activity. The steps include the downloading to a media, delivery of the media to the maintenance facilities and transfer of the data from the media to a maintenance computer for analysis.

Computer systems are typically used to analyse and manage the aircraft maintenance/diagnostics for the aircraft. Such systems require manual transportation of the down load media from each aircraft to the maintenance centre.

Often times, radio frequency (RF) transmissions are used to transmit maintenance/diagnostic data relating to an aircraft. This technique, however, requires substantial investments to construct the RF transmission systems required for such a system to work. Furthermore, it is very expensive to create redundancy in such a system. Maintenance/diagnostic data can also be transmitted to an aircraft via a telephone system located in a terminal. Such a system, however, requires that the aircraft be docked at the gate before transmission begins, thereby resulting in not being able to transfer uploads to aircraft that are routinely parked on the tarmac, away from the gates when loading and unloading passengers and cargo. Furthermore, such a system requires an added step of transmitting the download maintenance/diagnostic data from the telephone system to the maintenance centre, increasing the cost of installing, operating, and maintaining such a system.

Thus, there is a need for an aircraft maintenance/diagnostics download system that automatically transfers aircraft/engine and maintenance/diagnostic

data to the airline's or operator's maintenance and engineering centre with little or no human involvement, and which relies on a widely available and reliable public wireless, public switch telephone network (PSTN), integrated services digital network (ISDN), and/or Internet delivery systems.

The present invention, which addresses this need, resides in a system, method and an article of manufacture for transmitting maintenance and diagnostic data from an aircraft.

According to one aspect of this invention there is provided an aircraft maintenance data transmission system, comprising:

an aircraft having an avionics system and a communications unit, wherein the avionics system comprises a plurality of line replaceable units, and wherein the communications unit is connected to each line replaceable;

a cellular infrastructure in communication with said communications unit after the aircraft has landed, wherein the communication is initiated automatically upon the landing of the aircraft; and

a data reception unit connected to the cellular infrastructure.

Preferably the line replaceable unit is an avionics line replaceable unit.

Conveniently the line replaceable unit is a an electronic engine control line replaceable unit.

Advantageously said data reception unit is in communication with said cellular infrastructure via a computer network.

Preferably the computer network is the Internet.

Conveniently said data reception unit is in communication with said cellular infrastructure via a telephone network.

Preferably the telephone network is a public switch telephone network.

Advantageously the telephone network is an integrated services digital telephone network.

Preferably said communications unit includes:

an avionics input/output interface;

a processor that is connected to the avionics input/output interface;

a multi-port serial card in communication with said processor;

a plurality of cell channels in communication with said multi-port serial card; and

one or more antennas in communication with said cell channels.

Conveniently said cellular infrastructure includes:

an antenna;

a transceiver subsystem in communication with said antenna; and

a controller in communication with said transceiver subsystem.

Advantageously said data reception unit includes:

a router; and

a processor in communication with said router, said processor having a storage unit.

According to another aspect of this invention there is provided an aircraft maintenance data system, comprising:

an avionics system that comprises a plurality of line replaceable units;

an avionics input/output interface that is connected each of the line replaceable units;

a processor that is connected to the avionics input/output interface;

a multi-port serial card that is connected to the processor; and

a plurality of cell channels connected to the multi port serial card, said cell channels for transmitting data via a cellular infrastructure after the aircraft has landed, wherein the communication between the cell channels and the multi port serial card is automatically initiated upon the landing of the aircraft.

The system may further comprise one or more antennas in communication with said cell channels.

Advantageously the processor is a personal computer.

Alternatively the processor is an application specific integrated circuit.

Alternatively the processor is a microprocessor.

The invention also relates to an aircraft, comprising:

an avionics system having a plurality of line replaceable units; and

a communications unit connected to each of the line replaceable units, comprising:

an avionics input/output interface;

a processor connected to the avionics input/output interface;

a multi-port serial card connected to the processor; and

a plurality of cell channels connected to the multi port serial card, said cell channels for transmitting data via a cellular infrastructure after the aircraft

has landed, wherein the communication between the cell channels and the multi port serial card is automatically initiated upon the landing of the aircraft.

The invention further relates to an aircraft data transmission system, the aircraft having an avionics system, comprising:

means for transmitting data from the avionics system via a cellular infrastructure after the aircraft has landed, wherein the transmission of the data is initiated automatically upon landing of the aircraft; and

means for receiving said data from said cellular infrastructure.

Conveniently said means for transmitting data includes a processor.

Preferably said means for receiving data includes a processor.

The invention also relates to a method of transmitting maintenance and diagnostic data from an aircraft, comprising:

at the aircraft;

receiving the maintenance and diagnostic data from a plurality line replaceable units;

transmitting the maintenance and diagnostic data via a cellular communications infrastructure after the aircraft has landed, wherein the cellular communications infrastructure is accessed automatically upon landing of the aircraft; and

at a data reception unit, receiving the transmitted maintenance and diagnostic data.

In a further embodiment the invention relates to a method of transmitting maintenance and diagnostic data from an avionics system located on an aircraft, comprising:

receiving the maintenance and diagnostic data from a plurality of line replaceable units;

processing maintenance and diagnostic data; and

transmitting the processed maintenance and diagnostic data via a cellular infrastructure after the aircraft has landed, wherein the cellular infrastructure is accessed automatically upon landing of the aircraft.

The method may further comprise receiving said transmitted data at a flight operations centre.

Alternatively the method may further comprise receiving said transmitted data at a flight operations centre via a computer network.

Alternatively the method may further comprise receiving said transmitted data at a flight operations centre via a telephone network.

Preferably processing said data includes:

compressing the data;

encrypting the data;

segmenting the data; and

constructing packets of data from said segmented data.

Conveniently receiving said transmitted data includes:

acknowledging receipt of said transmitted data;

reassembling said received data;

decrypting said reassembled data;

uncompressing said decrypted data; and

storing said uncompressed data.

The invention may be considered to relate to a method of transmitting maintenance and diagnostic data from an aircraft, comprising:

receiving data from a plurality of line replaceable units;

processing the data; and

transmitting the processed data via a cellular infrastructure after the aircraft has landed, wherein processing said data includes:

receiving a signal which indicates that the data transmission process can begin;

initiating a data transfer;

compressing said data;

encrypting said compressed data;

creating a packet queue;

starting a primary data thread;

waiting a predetermined period of time;

determining if any threads are active;

repeating, when threads are active, the steps of waiting a predetermined period of time and determining if any threads are active; and

exiting processing said data when no threads are active.

Preferably starting a primary data thread includes:

initiating a PPP connection;

initiating a transfer session;

starting at least one secondary data thread;

determining if data remains in the primary data thread;

sending said data when data remains in the primary data thread;

determining if data threads are active when no data remains in the primary data thread;

repeating, when said threads are active, the step of determining if data remains in the primary data thread;

ending said session when no threads are active;

closing said PPP connection; and

exiting starting a primary data thread.

Conveniently starting at least one secondary data thread includes:

(a) setting the secondary data thread to active;

(b) initiating a PPP connection;

(c) determining if data remains in the secondary data thread;

(d) sending a data packet when data remains;

(e) repeating step c when data remains;

(f) closing said PPP connection when no data remains;

(g) setting the secondary data thread to inactive;

(h) exiting starting at least one secondary data thread; and

(i) repeating steps a through h for each secondary data thread.

Advantageously repeating steps a through h includes repeating steps a through h in parallel for each said secondary data thread.

The invention also relates to a computer-implemented method of transmitting maintenance and diagnostic data from an aircraft, comprising:

receiving the maintenance and diagnostic data from a plurality of line replaceable units;

processing the maintenance and diagnostic data; and

transmitting the processed data via a cellular infrastructure after the aircraft has landed; and

receiving the transmitted data at a flight operations centre, wherein receiving said transmitted data includes:

creating a socket;

receiving a message;

determining if said message is an initialisation message;

initiating a session when said message is an initialisation message;

determining if said message is a data message when said message is not an initialisation message;

processing said message when said message is a data message;

determining if said message is an end session when said message is not a data message;

processing said message when said message is an end session; and

repeating, when said message is not an end session message, the step of receiving a message.

Preferably initiating a session includes:

allocating buffer space;

sending an initiation session acknowledgement; and

returning to receiving a message.

Advantageously processing said message when said message is a data message includes:

copying said message to a buffer;

sending a data message acknowledgement; and

returning to receiving a message.

Preferably processing said message when said message is not an end session includes:

computing a checksum;

determining if said checksum is valid;

saving a buffer to a temporary file;

decrypting said temporary file;

uncompressing said temporary file;

sending an end session acknowledgement; and

returning to receiving a message.

The invention also relates to an article of manufacture comprising a computer program carrier, readable by a processor and embodying one or more instructions executable by the processor to perform the method of transmitting maintenance and diagnostic data from an avionics system located on an aircraft, the method comprising:

receiving maintenance and diagnostic data from a plurality of line replaceable units;

processing said maintenance and diagnostic data to prepare said data for transmission; and

transmitting said processed data via a cellular infrastructure when said aircraft has landed, wherein the cellular infrastructure is accessed automatically upon landing of the aircraft.

The system comprises an aircraft, a cellular infrastructures and a data reception unit. The aircraft has an avionics system and a communications unit. The avionics system comprises a plurality of line replaceable units. The communications unit is connected to each line replaceable unit. The cellular infrastructure is in communication with said communications unit after the aircraft has landed. The communication is initiated automatically upon the landing of the aircraft. The data reception unit is connected to the cellular infrastructure.

The preferred embodiment of the present invention represents a substantial advance over prior aircraft data download systems. For example, the present invention has the advantage that it requires little expense to implement because it uses well-known cellular technology, cellular infrastructure, telephone networks and computer networks, which are already in place. The preferred embodiment of the present invention also has the advantage that it can transmit the diagnostic data over one or more channels to achieve the necessary transmission bandwidth and achieve a low data transmission time. The preferred embodiment of the present invention has the further advantage that it does not require a dedicated data link between the aircraft and the airline/aircraft operator engineering centre and/or an airport terminal.

For the present invention to be clearly understood and readily practised, the present invention will be described in conjunction with the following figures, in which like reference numbers represent corresponding parts throughout:

FIGURE 1 illustrates an exemplary aircraft maintenance data download and transmission system, in accordance with an embodiment of the present invention;

FIGURE 2 is a block diagram illustrating a more detailed embodiment of the system illustrated in FIGURE 1, in accordance with an embodiment of the present invention;

FIGURE 3 is a block diagram illustrating data flow through the system illustrated in FIGURE 2, in accordance with an embodiment of the present invention;

FIGURE 4 is a flowchart illustrating a method carried out by the GroundLink processor in the aircraft, in accordance with an embodiment of the present invention;

FIGURE 5 is a flowchart illustrating a method of performing the start secondary data threads and transmitting data packet step 89 of FIGURE 4, in accordance with an embodiment of the present invention;

FIGURE 6 is a flowchart illustrating a method of performing the start secondary data threads step 103 of FIGURE 5, in accordance with an embodiment of the present invention;

FIGURE 7 is a flowchart illustrating a method of operating the GroundLink computer in the airlines/operators engineering centre, in accordance with an embodiment of the present invention;

FIGURE 8 is a flowchart illustrating a method of performing the process end of session step 152 of FIGURE 7, in accordance with an embodiment of the present invention;

FIGURE 9 is a block diagram illustrating another embodiment of the system illustrated in FIGURE 1.

In the following description, reference is made to the accompanying drawings which form a part hereof, and which is shown only by way of illustration a specific embodiment in which the invention may be practised. It is to be understood that other embodiments may be utilized and changes may be made without departing from scope of the present invention.

It is to be understood that the figures and descriptions of the present invention have been simplified to illustrate elements that are relevant for a clear understanding of the present invention, while eliminating, for purposes of clarity, other elements found in a typical communications system. It can be recognised that other elements are desirable and/or required to implement a device incorporating the present invention. For example, the details of the avionics and engine maintenance data download method, the cellular communications infrastructure, the Internet, and the public-switched telephone network are not disclosed. However, because such elements are well known in the art, and because they do not facilitate a better understanding of the present invention, a discussion of such elements is not provided herein.

FIGURE 1 illustrates an exemplary aircraft transmission/reception of avionics and engine maintenance/diagnostic data download system 10, in accordance with an embodiment of the present invention. An aircraft 12, which has stored avionics and electronic engine control units maintenance/diagnostics data, is illustrated after landing. The aircraft 12 transmits maintenance/diagnostics data as cellular communications signals over a cellular infrastructure 14. The cellular infrastructure 14 acts as a communications channel to the communications medium 16. Airline/operators engineering centre 18 is connected to the medium 16 by any conventional connectivity medium such as, for example, a leased line. Once the cellular connections are made via the medium 16 data can flow bidirectionally to and from the aircraft.

FIGURE 2 is a block diagram illustrating a more detailed embodiment of system 10 illustrated in FIGURE 1, in accordance with an embodiment of the present invention. The aircraft 12 includes avionics system 55 having a suite (1 through N) of avionics (and electronic engine control) line replaceable units

(LRU). Each avionics and electronic engine control line replaceable unit includes a storage media for storing maintenance/diagnostics data in a digital format.

The maintenance/diagnostics data are transferred from the avionics and electronic engine control unit LRU 55 to the communications unit 26 via a bus 28. The bus 28 is connected to an avionics I/O interface 30 in the communications unit 26. The avionics I/O interface 30 can be a standard bus interface such as, for example, an ARINC 429 bus, RS-232/422 or Ethernet.

The avionics I/O interface 30 is connected to a GroundLink processor 32. The GroundLink processor 32 can be a general purpose processor such as a personal computer, a microprocessor such as an Intel Pentium.RTM processor, or a special purpose processor such as an application specific integrated circuit (ASIC) designed to operate in the system 10. The GroundLink processor is connected to one or more cellular channels 36 via multi port serial card 34.

The GroundLink processor 32 is responsive to an engine shut-off (or equivalent) signal, which notifies the GroundLink processor 32 to initiate transmission of the data after the aircraft 12 has landed. Upon receipt of this signal, the processor 32 acquires the maintenance/diagnostic data from the avionics LRU 55 via the avionics 1/O 30, and transmits the data to a multi-port serial card 34. Each 1/O port of the card 34 is attached to a cellular channel 36 which can open, sustain, and close a physical, over-the-air, channel to the cellular infrastructure 14. The cellular channels 36 can transmit and receive simultaneously and can thus transmit and receive data in parallel. Each cellular channel 36 is connected to an antenna matching network. One or more antennas 38 are installed in the aircraft 12 so as to optimise free space radiation to the cellular infrastructure 14.

The data are transmitted over cellular air link using the physical layer modulation of the cellular infrastructure 14. The cellular infrastructure 14 includes an antenna 40, which is within free-space radiating range of the aircraft 12. The antenna 40 is connected to a cellular base station transceiver subsystem 42. The subsystem 42 is connected to a cellular base station controller 44 which has a direct connection via a router (not shown) to the Internet 45. The data is transmitted via the Internet 45 to the airline/operators engineering centre 18.

A local router 46 in the airline/operators engineering centre 18 is connected to the Internet 45, such as via a connection to the backbone of the Internet 45. The router 46 connects a local area network 48 to the Internet 45. The local area network can be of any type of network such as, for example, a token ring network, an ATM network, or an Ethernet network. A GroundLink computer 50 is connected to the network 48 and receives the maintenance/diagnostics data from the specific aircraft tail number for storage in the attached storage unit 52 for analysis by related application programs. The storage unit 52 can be any type of unit capable of storing data such as, for example; disk drive or a disk array.

Data transfer can also occur from airline/operators engineering centre 18 to the aircraft 12. The data are transmitted over the Internet 45 and cellular infrastructure 14 and received by antenna 38. The serial card 34 receives the data from the cellular channels 38 and processor 32 outputs the data via the avionics I/O 30 to avionics 55 via bus 28.

FIGURE 3 is a block diagram illustrating data flow through the system 10 illustrated in FIGURE 2, in accordance with an embodiment of the present

invention. The maintenance data files are stored by the avionics LRUs. An application layer 58 of an operating system 60 of the GroundLink processor 32 acquires, compresses, encrypts, and segments the data files. The operating system 60 can be any type of operating system suitable such as, for example, UNIX. A typical stored file may be compressed from approximately 1 Mbytes to approximately 100 Kbytes. Compression may be done by any compression method such as, for example, the method embodied in the PKZIP.RTM. compression utility, manufactured by PKWARE, Inc. Encryption can be accomplished using any suitable asymmetric (public key) or symmetric encryption method such as, for example, the method embodied in Data Encryption Software (DES), manufactured by American Software Engineering or the methods in the RC2, RC4, or RC5 encryption software manufactured by RSA Data Security, Inc. During segmentation, individual datagrams of, for example, 1024 bytes are formed and indexed for subsequent reassemble.

The operating system 60 passes the datagrams to a network layer 62 which constructs UDP/IP packets from the datagrams by adding message headers to the datagrams. The network layer 62 then routes the packets to one of up to a fixed number (*e.g.*, 16) peer-to-peer protocol (PPP) threads running within the operating system 60 at a data link layer interface 64. The PPP convey the packets trough the multi port serial card 34 to the cellular channels 36. The packets are routed through the cellular infrastructure 14 to the Internet 45. The packets are received from the Internet 45 by the local router 46 in the airline/operators engineering centre 18. The network layer 62 receives acknowledgements of received packets from the GroundLink computer 50 in the airline/operators engineering centre 18. The network layer 62 also re-queues packets that are dropped before reaching the GroundLink computer 50.

The local router 46 in the airline/operators engineering centre 18 receives the packets and routes them to the GroundLink computer 50. A local network interface 68 receives the packets and a data link layer interface 70 of an operating system 72 passes the packets to a network layer 74 of the operating system 72. The operating system 72 can be any type of suitable operating system such as, for example Windows. The network layer 74 sends acknowledgements of successful packet deliveries to the GroundLink processor 32. The network layer 74 also removes the UPD/IP headers and passes the datagrams to an application layer 76. The application layer 76 reassembles, decrypts, and uncompresses the datagrams to restore the file to its original form. The application layer then passes the file 78 to the storage unit 52. The functions performed by the aircraft 12 and the airline/operator engineering centre 18 are similarly interchangeable when data is transferred from the airline/operator engineering centre 18 to the aircraft 12.

FIGURE 4 is a flowchart illustrating a method carried out by the GroundLink processor 32 in the aircraft, in accordance with an embodiment of the present invention. At step 81, the GroundLink processor 32 receives a "engine shut-off', or similar signal which indicates that data transmission process can be started and the GroundLink processor 32 initiates a data transfer by acquiring maintenance/diagnostics data files from avionics LRUs 55. At step 83, the application layer 58 compresses the acquired files and at step 84 it encrypts the file. At 86 the data is segmented into datagrams and UPD/IP packets are created and the packets are placed in a queue. The packets are ready for transmission over fixed number of threads, corresponding to the number of cellular channels 36. At step 89, the primary data thread is started to make the initial call and open the communications channel to the airline/operators engineering centre 18. There is a wait period, for example five seconds, inserted at step 91, and the status of the threads is tested for active

state at step 92. If any thread is found active the process loops back to the wait state. If there are no active channels detected at step 92 this method exits at step 93.

FIGURE 5 is a flowchart illustrating a method of performing the start primary data thread step 89 of FIGURE 4, in accordance with an embodiment of the present invention. At step 100 point to point (PPP) connection is initiated. At step 102 the process session is initiated. The secondary data threads are opened at step 103.

At step 104, it is determined if more packets are left to be transmitted. If so, the next packet in the data thread is transmitted at step 106 and the process loops back to step 104 to check if any more packet is available for transmission. If no packets are left to transmit, as determined at step 104, the state of the data threads is checked at step 108. If any data thread is found active at 108, then the process returns to step 104 to see if more data is to be transmitted. If it is found at step 108 that there is no active data thread then the session is ended at step 110. The PPP connections are closed at step 112 and the method exits at step 114.

FIGURE 6 is a flowchart illustrating a method of starting secondary data threads of step 103 of FIGURE 5, in accordance with an embodiment of the present invention. All the available secondary data threads are set active in step 118 by the data link interface 64. At step 120 the point to point (PPP) connections are initiated for each secondary data thread through the cellular channels 36 by the data link layer 64. At step 122 a test is made to determine if there are data packets for transmission. If packet is available, it is sent in step 124 to the GroundLink computer. If there is no more data packets to be sent, as

determined in step 122, the PPP connections are closed in step 126. The thread is set inactive in step 128 and the thread exits at step 130.

FIGURE 7 is a flowchart illustrating a method of operating the GroundLink computer 50 in the airline/operators engineering centre 18, in accordance with an embodiment of the present invention. In response to the call placed by the GroundLink processor 32 through the primary channel a socket is opened at step 132 by the operating system 72 in the computer 50 to receive messages transported across the Internet 45. At step 134, the computer 50 waits for a message from the Internet 45. When an initiate session message is received as determined at step 136, the application layer 76 allocates buffer space at step 138, sends a session acknowledgement message at step 140 to the GroundLink processor 32 on the aircraft 12 and the method returns to wait for additional messages at step 134. If the message received was a data packet, as determined at step 142, the network layer 74 removes the UDP/IP header and copies the datagram to the buffer in step 144. At step 146 the network layer 74 sends an acknowledge message to the GroundLink processor 32 on the aircraft 12.

If end session message is detected at step 148 the application layer 76 performs a process end session at step 152 and returns to wait for message step 134.

FIGURE 8 is a flowchart illustrating the steps included in the end session process step 152 of FIGURE 7, in accordance with an embodiment of the present invention. At step 160, the checksum is computed by the application layer 76 for the received data to check the integrity of the data. The checksum is checked at step 162 and if it is found to be correct the GroundLink computer 50 saves the buffer to a temporary file at step 164. The application

layer 76 of the GroundLink computer 50 then decrypts the file at step 166 and uncompresses the file at step 168. The uncompressed file 78 is stored at step 170 by the operating system 72 on storage unit 52. The GroundLink computer 50 sends an end session acknowledge message to the GroundLink processor 32 on aircraft 12 at step 174 and at step 178 the flow returns to step 134 of FIGURE 7. If the checksum is not correct, as determined at step 162, the GroundLink computer 50 sends an unsuccessful end session message (Nack) at step 176, which notifies the GroundLink processor 32 to re-send the data and the flow returns to step 134 of FIGURE 7.

FIGURE 9 is a block diagram illustrating another embodiment of the system 10 illustrated in FIGURE 1. The operation of the system 10 of FIGURE 9 is similar to that described in conjunction with the system 10 of FIGURE 2. However, the data that is transmitted by the GroundLink processor 32 via the cellular infrastructure 14 is routed by the public switched telephone network (PSTN) 210 to the modem bank 212. A modem bank 212 transmits the data to the GroundLink computer 50 via the local router 46 and local network 48. The modem bank 212 can have a modem dedicated to receive data from each one of the cellular channels 36.

While the present invention has been described in conjunction with preferred embodiments thereof, many modifications and variations will be apparent to those of ordinary skill in the art. For example, although the system has been described hereinabove as transferring data from the aircraft, the system can also be used to transfer data to the aircraft with no modifications in the system. Also, the system may be used to transmit data while the aircraft is in flight. Furthermore, the system may be used without encryption and without data compression prior to sending data. The foregoing description and the following claims are intended to cover all such modifications and variations.

In the present Specification "comprises" means "includes or consists of" and "comprising" means "including or consisting of".

The features disclosed in the foregoing description, or the following Claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS

1. An aircraft maintenance data transmission system, comprising:

an aircraft having an avionics system and a communications unit, wherein the avionics system comprises a plurality of line replaceable units, and wherein the communications unit is connected to each line replaceable;

a cellular infrastructure in communication with said communications unit after the aircraft has landed, wherein the communication is initiated automatically upon the landing of the aircraft; and

a data reception unit connected to the cellular infrastructure.

2. The aircraft maintenance data transmission system of claim 1, wherein the line replaceable unit is an avionics line replaceable unit.

3. The aircraft maintenance data transmission system of claim 1, wherein the line replaceable unit is a an electronic engine control line replaceable unit.

4. The aircraft maintenance data transmission system of claim 1, 2 or 3, wherein said data reception unit is in communication with said cellular infrastructure via a computer network.

5. The aircraft maintenance data transmission system of claim 4, wherein the computer network is the Internet.

6. The aircraft maintenance data transmission system of claim 1, 2 or 3, wherein said data reception unit is in communication with said cellular infrastructure via a telephone network.

7. The aircraft maintenance data transmission system of claim 6, wherein the telephone network is a public switch telephone network.

8. The aircraft maintenance data transmission system of claim 6, wherein the telephone network is an integrated services digital telephone network.

9. The aircraft maintenance data transmission system of any one of claims 1 to 8, wherein said communications unit includes:

an avionics input/output interface;

a processor that is connected to the avionics input/output interface;

a multi-port serial card in communication with said processor;

a plurality of cell channels in communication with said multi-port serial card; and

one or more antennas in communication with said cell channels.

10. The aircraft maintenance data transmission system of any one of claims 1 to 9, wherein said cellular infrastructure includes:

an antenna;

a transceiver subsystem in communication with said antenna; and

a controller in communication with said transceiver subsystem.

11. The aircraft maintenance data transmission system of any one of the preceding claims, wherein said data reception unit includes:

a router; and

a processor in communication with said router, said processor having a storage unit.

12. An aircraft maintenance data system, comprising:

an avionics system that comprises a plurality of line replaceable units;

an avionics input/output interface that is connected each of the line replaceable units;

a processor that is connected to the avionics input/output interface;

a multi-port serial card that is connected to the processor; and

a plurality of cell channels connected to the multi port serial card, said cell channels for transmitting data via a cellular infrastructure after the aircraft has landed, wherein the communication between the cell channels and the multi port serial card is automatically initiated upon the landing of the aircraft.

13. The aircraft maintenance data system of claim 12, further comprising one or more antennas in communication with said cell channels.

14. The aircraft maintenance data system of claim 12 or 13, wherein the processor is a personal computer.

15. The aircraft maintenance data system of claim 12 or 13, wherein the processor is an application specific integrated circuit.

16. The aircraft maintenance data system of claim 12 or 13, wherein the processor is a microprocessor.

17. An aircraft, comprising:

an avionics system having a plurality of line replaceable units; and

a communications unit connected to each of the line replaceable units, comprising:

an avionics input/output interface;

a processor connected to the avionics input/output interface;

a multi-port serial card connected to the processor; and

a plurality of cell channels connected to the multi port serial card, said cell channels for transmitting data via a cellular infrastructure after the aircraft has landed, wherein the communication between the cell channels and the multi port serial card is automatically initiated upon the landing of the aircraft.

18. An aircraft data transmission system, the aircraft having an avionics system, comprising:

means for transmitting data from the avionics system via a cellular infrastructure after the aircraft has landed, wherein the transmission of the data is initiated automatically upon landing of the aircraft; and

means for receiving said data from said cellular infrastructure.

19. The aircraft data transmission system of claim 18, wherein said means for transmitting data includes a processor.

20. The aircraft data transmission system of claim 18 or 19, wherein said means for receiving data includes a processor.

21. A method of transmitting maintenance and diagnostic data from an aircraft, comprising:

at the aircraft;

receiving the maintenance and diagnostic data from a plurality line replaceable units;

transmitting the maintenance and diagnostic data via a cellular communications infrastructure after the aircraft has landed, wherein the cellular communications infrastructure is accessed automatically upon landing of the aircraft; and

at a data reception unit, receiving the transmitted maintenance and diagnostic data.

22. A method of transmitting maintenance and diagnostic data from an avionics system located on an aircraft, comprising:

receiving the maintenance and diagnostic data from a plurality of line replaceable units;

processing maintenance and diagnostic data; and

transmitting the processed maintenance and diagnostic data via a cellular infrastructure after the aircraft has landed, wherein the cellular infrastructure is accessed automatically upon landing of the aircraft.

23. The method of claim 22, further comprising receiving said transmitted data at a flight operations centre.

24. The method of claim 22, further comprising receiving said transmitted data at a flight operations centre via a computer network.

25. The method of claim 22, further comprising receiving said transmitted data at a flight operations centre via a telephone network.

26. The method of any one of claims 19 to 26, wherein processing said data includes:

compressing the data;

encrypting the data;

segmenting the data; and

constructing packets of data from said segmented data.

27. The method of claim 22 or any claims dependent thereon, wherein receiving said transmitted data includes:

acknowledging receipt of said transmitted data;

reassembling said received data;

decrypting said reassembled data;

uncompressing said decrypted data; and

storing said uncompressed data.

28. A method of transmitting maintenance and diagnostic data from an aircraft, comprising:

receiving data from a plurality of line replaceable units;

processing the data; and

transmitting the processed data via a cellular infrastructure after the aircraft has landed, wherein processing said data includes:

receiving a signal which indicates that the data transmission process can begin;

initiating a data transfer;

compressing said data;

encrypting said compressed data;

creating a packet queue;

starting a primary data thread;

waiting a predetermined period of time;

determining if any threads are active;

repeating, when threads are active, the steps of waiting a predetermined period of time and determining if any threads are active; and

exiting processing said data when no threads are active.

29. The method of claim 28 wherein starting a primary data thread includes:

initiating a PPP connection;

initiating a transfer session;

starting at least one secondary data thread;

determining if data remains in the primary data thread;

sending said data when data remains in the primary data thread;

determining if data threads are active when no data remains in the primary data thread;

repeating, when said threads are active, the step of determining if data remains in the primary data thread;

ending said session when no threads are active;

closing said PPP connection; and

exiting starting a primary data thread.

30. The method of claim 29 wherein starting at least one secondary data thread includes:

(a) setting the secondary data thread to active;

(b) initiating a PPP connection;

(c) determining if data remains in the secondary data thread;

(d) sending a data packet when data remains;

(e) repeating step c when data remains;

(f) closing said PPP connection when no data remains;

(g) setting the secondary data thread to inactive;

(h) exiting starting at least one secondary data thread; and

(i) repeating steps a through h for each secondary data thread.

31. The method of claim 30, wherein repeating steps a through h includes repeating steps a through h in parallel for each said secondary data thread.

32. A computer-implemented method of transmitting maintenance and diagnostic data from an aircraft, comprising:

receiving the maintenance and diagnostic data from a plurality of line replaceable units;

processing the maintenance and diagnostic data; and

transmitting the processed data via a cellular infrastructure after the aircraft

has landed; and

receiving the transmitted data at a flight operations centre, wherein receiving said transmitted data includes:

creating a socket;

receiving a message;

determining if said message is an initialisation message;

initiating a session when said message is an initialisation message;

determining if said message is a data message when said message is not an initialisation message;

processing said message when said message is a data message;

determining if said message is an end session when said message is not a data message;

processing said message when said message is an end session; and

repeating, when said message is not an end session message, the step of receiving a message.

33. The method of claim 32 wherein initiating a session includes:

allocating buffer space;

sending an initiation session acknowledgement; and

returning to receiving a message.

34. The method of claim 32 or 33, wherein processing said message when said message is a data message includes:

copying said message to a buffer;

sending a data message acknowledgement; and

returning to receiving a message.

35. The method of claim 32, wherein processing said message when said message is not an end session includes:

computing a checksum;

determining if said checksum is valid;

saving a buffer to a temporary file;

decrypting said temporary file;

uncompressing said temporary file;

sending an end session acknowledgement; and

returning to receiving a message.

36. An article of manufacture comprising a computer program carrier, readable by a processor and embodying one or more instructions executable by the processor to perform the method of transmitting maintenance and diagnostic data from an avionics system located on an aircraft, the method comprising:

receiving maintenance and diagnostic data from a plurality of line replaceable units;

processing said maintenance and diagnostic data to prepare said data for transmission; and

transmitting said processed data via a cellular infrastructure when said aircraft has landed, wherein the cellular infrastructure is accessed automatically upon landing of the aircraft.

37. An aircraft maintenance data transmission system substantially as herein described with reference to and as shown in the accompanying drawings.

39. A method of transmitting maintenance and diagnostic data substantially as herein described with reference to and as shown in the accompanying drawings.

39. An aircraft substantially as herein described with reference to and as shown in the accompanying drawings.

40. An article of manufacture comprising a computer programme substantially as herein described with reference to and as shown in the accompanying drawings.

41. Any novel feature or combination of features disclosed herein.

ABSTRACT

"IMPROVEMENTS IN OR RELATING TO AIRCRAFT AVIONICS MAINTENANCE DIAGNOSITCS DATA DOWNLOAD TRANSMISSION SYSTEM"

The present invention resides in a system, method and an article of manufacture for transmitting maintenance and diagnostic data from an aircraft. The system comprises an aircraft, a cellular infrastructures and a data reception unit. The aircraft has an avionics system and a communications unit. The avionics system comprises a plurality of line replaceable units, and the communications unit is connected to each line replaceable unit. The cellular infrastructure is in communication with said communications unit after the aircraft has landed. The communication is initiated automatically upon the landing of the aircraft. The data reception unit is connected to the cellular infrastructure.

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December 01, 2003

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APPLICATION NUMBER: *10/272,753*
FILING DATE: *October 17, 2002*

By Authority of the
COMMISSIONER OF PATENTS AND TRADEMARKS

L. Edelen

L. EDELEN
Certifying Officer

Express Mail Label No. EL 900 688 377 US 10-18-02 2272753.101702 A

JC511 U.S. PTO 10/17/02

UTILITY PATENT APPLICATION TRANSMITTAL
(Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No. 21679-81051
Total Pages in this Submission 47

TO THE ASSISTANT COMMISSIONER FOR PATENTS
Box Patent Application
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for an invention entitled:

AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTICS DATA DOWNLOAD TRANSMISSION SYSTEM

JC997 U.S. PTO 10/272753 10/17/02

and invented by:

Tamas M. Igloi and Ghobad Karimi

If a CONTINUATION APPLICATION, *check appropriate box and supply the requisite information:*

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Enclosed are:

Application Elements

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 19 pages and including the following:
   - a. ☒ Descriptive Title of the Invention
   - b. ☒ Cross References to Related Applications *(if applicable)*
   - c. ☐ Statement Regarding Federally-sponsored Research/Development *(if applicable)*
   - d. ☐ Reference to Sequence Listing, a Table, or a Computer Program Listing Appendix
   - e. ☒ Background of the Invention
   - f. ☒ Brief Summary of the Invention
   - g. ☒ Brief Description of the Drawings *(if filed)*
   - h. ☒ Detailed Description
   - i. ☒ Claim(s) as Classified Below
   - j. ☒ Abstract of the Disclosure

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Application Elements (Continued)

3. ☒ Drawing(s) *(when necessary as prescribed by 35 USC 113)*
   a. ☒ Formal Number of Sheets 9
   b. ☐ Informal Number of Sheets
4. ☒ Oath or Declaration
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   b. ☐ Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional application only)*
   c. ☐ With Power of Attorney ☒ Without Power of Attorney
   d. ☐ *DELETION OF INVENTOR(S)*
   Signed statement attached deleting inventor(s) named in the prior application, see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference *(usable if Box 4b is checked)*
   The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.
6. ☐ CD ROM or CD-R in duplicate, large table or Computer Program (Appendix)
7. ☐ Application Data Sheet (See 37 CFR 1.76)
8. ☐ Nucleotide and/or Amino Acid Sequence Submission *(if applicable, all must be included)*
   a. ☐ Computer Readable Form (CRF)
   b. ☐ Specification Sequence Listing on:
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      ii. ☐ Paper
   c. ☐ Statement(s) Verifying Identical Paper and Computer Readable Copy

Accompanying Application Parts

9. ☒ Assignment Papers *(cover sheet & document(s))*
10. ☒ 37 CFR 3.73(B) Statement *(when there is an assignee)*
11. ☐ English Translation Document *(if applicable)*
12. ☐ Information Disclosure Statement/PTO-1449 ☐ Copies of IDS Citations
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UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity) *(Only for new nonprovisional applications under 37 CFR 1.53(b))*	Docket No. 21679-81051
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Accompanying Application Parts (Continued)

17. ☒ Additional Enclosures *(please identify below):*

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Request That Application Not Be Published Pursuant To 35 U.S.C. 122(b)(2)

18. ☐ Pursuant to 35 U.S.C. 122(b)(2), Applicant hereby requests that this patent application not be published pursuant to 35 U.S.C. 122(b)(1). Applicant hereby certifies that the invention disclosed in this application has not and will not be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication of applications 18 months after filing of the application.

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10272753.1041702

UTILITY PATENT APPLICATION TRANSMITTAL
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Fee Calculation and Transmittal

CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	36	- 20 =	16	x $18.00	$288.00
Indep. Claims	9	- 3 =	6	x $84.00	$504.00
Multiple Dependent Claims (check if applicable) ☐					$0.00
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Denise L. McKenzie
Signature

Dated: October 17, 2002

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Serial No. UNASSIGNED	Filing Date October 17, 2002	Examiner –	Group Art Unit –

Invention:

AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTICS DATA DOWNLOAD TRANSMISSION SYSTEM

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Our Docket No. 21679-81051 PATENTS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Tamas M. Igloi and Ghobad Karimi
Serial No.: Unassigned
Filed on: Herewith
Title: **AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTIC DATA DOWNLOAD TRANSMISSION SYSTEM**

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Date: 10/9/2002

Name: Melanie S. Cibik, Esq.
Title: Vice President and Assistant Secretary
Signature: Melanie S. Cibik

LA1 456950v1

[redacted]

U.S. PATENT APPLICATION

OF

TAMAS M. IGLOI

AND

GHOBAD KARIMI

FOR

UNITED STATES LETTERS PATENT

ON

AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTICS DATA DOWNLOAD TRANSMISSION SYSTEM

Docket: 21679-81051
Sheets of Drawings: 9

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AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTICS DATA DOWNLOAD TRANSMISSION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is related to the commonly-assigned U.S. Patent No. 6,181,990, entitled "AIRCRAFT FLIGHT DATA ACQUISITION AND TRANSMISSION SYSTEM," issued on January 30, 2001.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed generally to an aircraft maintenance/diagnostic data transmission system and, more particularly, to on-board cellular data transmission/reception system in conjunction with maintenance/diagnostics data transmission over public telephone networks and the Internet.

2. Description of the Related Art

It is common for aircraft avionics and electronic engine control systems to require download of maintenance/diagnostic data for maintenance purposes. Presently, most aircraft utilized in passenger, freighter and business categories require some degree of diagnostic data download from one or more avionics and engine control equipment, such as an Electronic Engine Computer (EEC), Data Encryption Unit (DEU), Flight Management Computer (FMC), etc. These downloads are currently accomplished manually by connecting a download device to the aircraft, or using permanently installed maintenance/diagnostics terminals. The diagnostic information is transferred from the avionics equipment to storage media, such as floppy disks or CD-ROMs. Upon completion of the transfer from the avionics unit to the storage media, the maintenance/diagnostic information is transferred to the maintenance center of the airline for processing.

The current manual download includes the human as an active component of this activity. The steps include the downloading to a media, delivery of the media to the maintenance facilities and transfer of the data from the media to a maintenance computer for analysis.

Computer systems are typically used to analyze and manage the aircraft maintenance/diagnostics for the aircraft. Such systems require manual transportation of the down load media from each aircraft to the maintenance center.

Often times, radio frequency (RF) transmissions are used to transmit maintenance/diagnostic data relating to an aircraft. This technique, however, requires substantial investments to construct the RF transmission systems required for such a system to work. Furthermore, it is very expensive to create redundancy in such a system.

Maintenance/diagnostic data can also be transmitted to an aircraft via a telephone system located in a terminal. Such a system, however, requires that the aircraft be docked at the gate before transmission begins, thereby resulting in not being able to transfer uploads to aircraft that are routinely parked on the tarmac, away from the gates when loading and unloading passengers and cargo. Furthermore, such a system requires an added step of transmitting the download maintenance/diagnostic data from the telephone system to the maintenance center, increasing the cost of installing, operating, and maintaining such a system.

Thus, there is a need for an aircraft maintenance/diagnostics download system that automatically transfers aircraft/engine and maintenance/diagnostic data to the airline's or operator's maintenance and engineering center with little or no human involvement, and which relies on a widely available and reliable public wireless, public switch telephone network (PSTN), integrated services digital network (ISDN), and/or Internet delivery systems.

SUMMARY OF THE INVENTION

The present invention, which addresses this need, resides in a system, method and an article of manufacture for transmitting maintenance and diagnostic data from an aircraft.

The system comprises an aircraft, a cellular infrastructures and a data reception unit. The aircraft has an avionics system and a communications unit. The avionics system comprises a plurality of line replaceable units. The communications unit is connected to each line replaceable unit. The cellular infrastructure is in communication with said communications unit after the aircraft has landed. The communication is initiated automatically upon the landing of the aircraft. The data reception unit is connected to the cellular infrastructure.

The present invention represents a substantial advance over prior aircraft data download systems. For example, the present invention has the advantage that it requires little expense to implement because it uses well-known cellular technology, cellular infrastructure, telephone networks and computer networks, which are already in place. The present invention also has the advantage that it can transmit the diagnostic data over one or more channels to achieve the necessary transmission bandwidth and achieve a low data transmission time. The present invention has the further advantage that it does not require a dedicated data link between the aircraft and the airline/aircraft operator engineering center and/or an airport terminal.

BRIEF DESCRIPTION OF THE DRAWING

For the present invention to be clearly understood and readily practiced, the present invention will be described in conjunction with the following figures, in which like reference numbers represent corresponding parts throughout:

FIGURE 1 illustrates an exemplary aircraft maintenance data download and transmission system, in accordance with an embodiment of the present invention;

FIGURE 2 is a block diagram illustrating a more detailed embodiment of the system illustrated in FIGURE 1, in accordance with an embodiment of the present invention;

FIGURE 3 is a block diagram illustrating data flow through the system illustrated in FIGURE 2, in accordance with an embodiment of the present invention;

FIGURE 4 is a flowchart illustrating a method carried out by the GroundLink processor in the aircraft, in accordance with an embodiment of the present invention;

FIGURE 5 is a flowchart illustrating a method of performing the start secondary data threads and transmitting data packet step 89 of FIGURE 4, in accordance with an embodiment of the present invention;

FIGURE 6 is a flowchart illustrating a method of performing the start secondary data threads step 103 of FIGURE 5, in accordance with an embodiment of the present invention;

FIGURE 7 is a flowchart illustrating a method of operating the GroundLink computer in the airlines/operators engineering center, in accordance with an embodiment of the present invention;

FIGURE 8 is a flowchart illustrating a method of performing the process end of session step 152 of FIGURE 7, in accordance with an embodiment of the present invention;

FIGURE 9 is a block diagram illustrating another embodiment of the system illustrated in FIGURE 1.

[redacted]

DETAILED DESCRIPTION OF THE INVENTION

In the following description, reference is made to the accompanying drawings which form a part hereof, and which is shown only by way of illustration a specific embodiment in which the invention may be practiced. It is to be understood that other embodiments may be utilized and changes may be made without departing from scope of the present invention

It is to be understood that the figures and descriptions of the present invention have been simplified to illustrate elements that are relevant for a clear understanding of the present invention, while eliminating, for purposes of clarity, other elements found in a typical communications system. It can be recognized that other elements are desirable and/or required to implement a device incorporating the present invention. For example, the details of the avionics and engine maintenance data download method, the cellular communications infrastructure, the Internet, and the public-switched telephone network are not disclosed. However, because such elements are well known in the art, and because they do not facilitate a better understanding of the present invention, a discussion of such elements is not provided herein.

FIGURE 1 illustrates an exemplary aircraft transmission/reception of avionics and engine maintenance/diagnostic data download system 10, in accordance with an embodiment of the present invention. An aircraft 12, which has stored avionics and electronic engine control units maintenance/diagnostics data, is illustrated after landing. The aircraft 12 transmits maintenance/diagnostics data as cellular communications signals over a cellular infrastructure 14. The cellular infrastructure 14 acts as a communications channel to the communications medium 16. Airline/operators engineering center 18 is connected to the medium 16 by any conventional connectivity medium such as, for example, a leased line. Once the cellular connections are made via the medium 16 data can flow bidirectionally to and from the aircraft.

FIGURE 2 is a block diagram illustrating a more detailed embodiment of system 10 illustrated in FIGURE 1, in accordance with an embodiment of the present

invention. The aircraft 12 includes avionics system 55 having a suite (1 through N) of avionics (and electronic engine control) line replaceable units (LRU). Each avionics and electronic engine control line replaceable unit includes a storage media for storing maintenance/diagnostics data in a digital format.

The maintenance/diagnostics data are transferred from the avionics and electronic engine control unit LRU 55 to the communications unit 26 via a bus 28. The bus 28 is connected to an avionics I/O interface 30 in the communications unit 26. The avionics I/O interface 30 can be a standard bus interface such as, for example, an ARINC 429 bus, RS-232/422 or Ethernet.

The avionics I/O interface 30 is connected to a GroundLink processor 32. The GroundLink processor 32 can be a general purpose processor such as a personal computer, a microprocessor such as an Intel Pentium.RTM processor, or a special purpose processor such as an application specific integrated circuit (ASIC) designed to operate in the system 10. The GroundLink processor is connected to one or more cellular channels 36 via multi port serial card 34.

The GroundLink processor 32 is responsive to an engine shut-off (or equivalent) signal, which notifies the GroundLink processor 32 to initiate transmission of the data after the aircraft 12 has landed. Upon receipt of this signal, the processor 32 acquires the maintenance/diagnostic data from the avionics LRU 55 via the avionics I/O 30, and transmits the data to a multi-port serial card 34. Each I/O port of the card 34 is attached to a cellular channel 36 which can open, sustain, and close a physical, over-the-air, channel to the cellular infrastructure 14. The cellular channels 36 can transmit and receive simultaneously and can thus transmit and receive data in parallel. Each cellular channel 36 is connected to an antenna matching network. One or more antennas 38 are installed in the aircraft 12 so as to optimize free space radiation to the cellular infrastructure 14.

The data are transmitted over cellular air link using the physical layer modulation of the cellular infrastructure 14. The cellular infrastructure 14 includes an

antenna 40, which is within free-space radiating range of the aircraft 12. The antenna 40 is connected to a cellular base station transceiver subsystem 42. The subsystem 42 is connected to a cellular base station controller 44 which has a direct connection via a router (not shown) to the Internet 45. The data is transmitted via the Internet 45 to the airline/operators engineering center 18.

A local router 46 in the airline/operators engineering center 18 is connected to the Internet 45, such as via a connection to the backbone of the Internet 45. The router 46 connects a local area network 48 to the Internet 45. The local area network can be of any type of network such as, for example, a token ring network, an ATM network, or an Ethernet network. A GroundLink computer 50 is connected to the network 48 and receives the maintenance/diagnostics data from the specific aircraft tail number for storage in the attached storage unit 52 for analysis by related application programs. The storage unit 52 can be any type of unit capable of storing data such as, for example; disk drive or a disk array.

Data transfer can also occur from airline/operators engineering center 18 to the aircraft 12. The data are transmitted over the Internet 45 and cellular infrastructure 14 and received by antenna 38. The serial card 34 receives the data from the cellular channels 38 and processor 32 outputs the data via the avionics I/O 30 to avionics 55 via bus 28.

FIGURE 3 is a block diagram illustrating data flow through the system 10 illustrated in FIGURE 2, in accordance with an embodiment of the present invention. The maintenance data files are stored by the avionics LRUs. An application layer 58 of an operating system 60 of the GroundLink processor 32 acquires, compresses, encrypts, and segments the data files. The operating system 60 can be any type of operating system suitable such as, for example, UNIX. A typical stored file may be compressed from approximately 1 Mbytes to approximately 100 Kbytes. Compression may be done by any compression method such as, for example, the method embodied in the PKZIP.RTM. compression utility, manufactured by PKWARE, Inc. Encryption can be accomplished using any suitable asymmetric (public key) or symmetric encryption method such as, for

example, the method embodied in Data Encryption Software (DES), manufactured by American Software Engineering or the methods in the RC2, RC4, or RC5 encryption software manufactured by RSA Data Security, Inc. During segmentation, individual datagrams of, for example, 1024 bytes are formed and indexed for subsequent reassemble.

The operating system 60 passes the datagrams to a network layer 62 which constructs UDP/IP packets from the datagrams by adding message headers to the datagrams. The network layer 62 then routes the packets to one of up to a fixed number (*e.g.*, 16) peer-to-peer protocol (PPP) threads running within the operating system 60 at a data link layer interface 64. The PPP convey the packets trough the multi port serial card 34 to the cellular channels 36. The packets are routed through the cellular infrastructure 14 to the Internet 45. The packets are received from the internet 45 by the local router 46 in the airline/operators engineering center 18. The network layer 62 receives acknowledgments of received packets from the GroundLink computer 50 in the airline/operators engineering center 18. The network layer 62 also re-queues packets that are dropped before reaching the GroundLink computer 50.

The local router 46 in the airline/operators engineering center 18 receives the packets and routes them to the GroundLink computer 50. A local network interface 68 receives the packets and a data link layer interface 70 of an operating system 72 passes the packets to a network layer 74 of the operating system 72. The operating system 72 can be any type of suitable operating system such as, for example Windows. The network layer 74 sends acknowledgements of successful packet deliveries to the GroundLink processor 32. The network layer 74 also removes the UPD/IP headers and passes the datagrams to an application layer 76. The application layer 76 reassembles, decrypts, and uncompresses the datagrams to restore the file to its original form. The application layer then passes the file 78 to the storage unit 52. The functions performed by the aircraft 12 and the airline/operator engineering center 18 are similarly interchangeable when data is transferred from the airline/operator engineering center 18 to the aircraft 12.

FIGURE 4 is a flowchart illustrating a method carried out by the GroundLink processor 32 in the aircraft, in accordance with an embodiment of the present invention. At step 81, the GroundLink processor 32 receives a "engine shut-off', or similar signal which indicates that data transmission process can be started and the GroundLink processor 32 initiates a data transfer by acquiring maintenance/diagnostics data files from avionics LRUs 55. At step 83, the application layer 58 compresses the acquired files and at step 84 it encrypts the file. At 86 the data is segmented into datagrams and UPD/IP packets are created and the packets are placed in a queue. The packets are ready for transmission over fixed number of threads, corresponding to the number of cellular channels 36. At step 89, the primary data thread is started to make the initial call and open the communications channel to the airline/operators engineering center 18. There is a wait period, for example five seconds, inserted at step 91, and the status of the threads is tested for active state at step 92. If any thread is found active the process loops back to the wait state. If there are no active channels detected at step 92 this method exits at step 93.

FIGURE 5 is a flowchart illustrating a method of performing the start primary data thread step 89 of FIGURE 4, in accordance with an embodiment of the present invention. At step 100 point to point (PPP) connection is initiated. At step 102 the process session is initiated. The secondary data threads are opened at step 103.

At step 104, it is determined if more packets are left to be transmitted. If so, the next packet in the data thread is transmitted at step 106 and the process loops back to step 104 to check if any more packet is available for transmission. If no packets are left to transmit, as determined at step 104, the state of the data threads is checked at step 108. If any data thread is found active at 108, then the process returns to step 104 to see if more data is to be transmitted. If it is found at step 108 that there is no active data thread then the session is ended at step 110. The PPP connections are closed at step 112 and the method exits at step 114.

FIGURE 6 is a flowchart illustrating a method of starting secondary data threads of step 103 of FIGURE 5, in accordance with an embodiment of the present

[redacted]

invention. All the available secondary data threads are set active in step 118 by the data link interface 64. At step 120 the point to point (PPP) connections are initiated for each secondary data thread through the cellular channels 36 by the data link layer 64. At step 122 a test is made to determine if there are data packets for transmission. If packet is available, it is sent in step 124 to the GroundLink computer. If there is no more data packets to be sent, as determined in step 122, the PPP connections are closed in step 126. The thread is set inactive in step 128 and the thread exits at step 130.

FIGURE 7 is a flowchart illustrating a method of operating the GroundLink computer 50 in the airline/operators engineering center 18, in accordance with an embodiment of the present invention. In response to the call placed by the GroundLink processor 32 through the primary channel a socket is opened at step 132 by the operating system 72 in the computer 50 to receive messages transported across the Internet 45. At step 134, the computer 50 waits for a message from the Internet 45. When an initiate session message is received as determined at step 136, the application layer 76 allocates buffer space at step 138, sends a session acknowledgement message at step 140 to the GroundLink processor 32 on the aircraft 12 and the method returns to wait for additional messages at step 134. If the message received was a data packet, as determined at step 142, the network layer 74 removes the UDP/IP header and copies the datagram to the buffer in step 144. At step 146 the network layer 74 sends an acknowledge message to the GroundLink processor 32 on the aircraft 12.

If end session message is detected at step 148 the application layer 76 performs a process end session at step 152 and returns to wait for message step 134.

FIGURE 8 is a flowchart illustrating the steps included in the end session process step 152 of FIGURE 7, in accordance with an embodiment of the present invention. At step 160, the checksum is computed by the application layer 76 for the received data to check the integrity of the data. The checksum is checked at step 162 and if it is found to be correct the GroundLink computer 50 saves the buffer to a temporary file at step 164. The application layer 76 of the GroundLink computer 50 then decrypts the file at step 166 and uncompresses the file at step 168. The uncompressed file 78 is

stored at step 170 by the operating system 72 on storage unit 52. The GroundLink computer 50 sends an end session acknowledge message to the GroundLink processor 32 on aircraft 12 at step 174 and at step 178 the flow returns to step 134 of FIGURE 7. If the checksum is not correct, as determined at step 162, the GroundLink computer 50 sends an unsuccessful end session message (Nack) at step 176, which notifies the GroundLink processor 32 to re-send the data and the flow returns to step 134 of FIGURE 7.

FIGURE 9 is a block diagram illustrating another embodiment of the system 10 illustrated in FIGURE 1. The operation of the system 10 of FIGURE 9 is similar to that described in conjunction with the system 10 of FIGURE 2. However, the data that is transmitted by the GroundLink processor 32 via the cellular infrastructure 14 is routed by the public switched telephone network (PSTN) 210 to the modem bank 212. A modem bank 212 transmits the data to the GroundLink computer 50 via the local router 46 and local network 48. The modem bank 212 can have a modem dedicated to receive data from each one of the cellular channels 36.

While the present invention has been described in conjunction with preferred embodiments thereof, many modifications and variations will be apparent to those of ordinary skill in the art. For example, although the system has been described hereinabove as transferring data from the aircraft, the system can also be used to transfer data to the aircraft with no modifications in the system. Also, the system may be used to transmit data while the aircraft is in flight. Furthermore, the system may be used without encryption and without data compression prior to sending data. The foregoing description and the following claims are intended to cover all such modifications and variations.

WHAT I CLAIM:

1. An aircraft maintenance data transmission system, comprising:

an aircraft having an avionics system and a communications unit, wherein the avionics system comprises a plurality of line replaceable units, and wherein the communications unit is connected to each line replaceable;

a cellular infrastructure in communication with said communications unit after the aircraft has landed, wherein the communication is initiated automatically upon the landing of the aircraft; and

a data reception unit connected to the cellular infrastructure.

2. The aircraft maintenance data transmission system of claim 1, wherein the line replaceable unit is an avionics line replaceable unit.

3. The aircraft maintenance data transmission system of claim 1, wherein the line replaceable unit is a an electronic engine control line replaceable unit.

4. The aircraft maintenance data transmission system of claim 1, wherein said data reception unit is in communication with said cellular infrastructure via a computer network.

5. The aircraft maintenance data transmission system of claim 4, wherein the computer network is the Internet.

6. The aircraft maintenance data transmission system of claim 1, wherein said data reception unit is in communication with said cellular infrastructure via a telephone network.

7. The aircraft maintenance data transmission system of claim 6, wherein the telephone network is a public switch telephone network.

8. The aircraft maintenance data transmission system of claim 6, wherein the telephone network is an integrated services digital telephone network.

9. The aircraft maintenance data transmission system of claim 1, wherein said communications unit includes:

an avionics input/output interface;

a processor that is connected to the avionics input/output interface;

a multi-port serial card in communication with said processor;

a plurality of cell channels in communication with said multi-port serial card;

and

one or more antennas in communication with said cell channels.

10. The aircraft maintenance data transmission system of claim 1, wherein said cellular infrastructure includes:

an antenna;

a transceiver subsystem in communication with said antenna; and

a controller in communication with said transceiver subsystem.

11. The aircraft maintenance data transmission system of claim 1, wherein said data reception unit includes:

a router; and

a processor in communication with said router, said processor having a storage unit.

12. An aircraft maintenance data system, comprising:

an avionics system that comprises a plurality of line replaceable units;

an avionics input/output interface that is connected each of the line replaceable units;

a processor that is connected to the avionics input/output interface;

a multi-port serial card that is connected to the processor; and

a plurality of cell channels connected to the multi port serial card, said cell channels for transmitting data via a cellular infrastructure after the aircraft has landed, wherein the communication between the cell channels and the multi port serial card is automatically initiated upon the landing of the aircraft.

13. The aircraft maintenance data system of claim 12, further comprising one or more antennas in communication with said cell channels.

14. The aircraft maintenance data system of claim 12, wherein the processor is a personal computer.

15. The aircraft maintenance data system of claim 12, wherein the processor is an application specific integrated circuit.

16. The aircraft maintenance data system of claim 12, wherein the processor is a microprocessor.

17. An aircraft, comprising:

an avionics system having a plurality of line replaceable units, and

a communications unit connected to each of the line replaceable units, comprising:

an avionics input/output interface;

a processor connected to the avionics input/output interface;

a multi-port serial card connected to the processor; and

a plurality of cell channels connected to the multi port serial card, said cell channels for transmitting data via a cellular infrastructure after the aircraft has landed, wherein the communication between the cell channels and the multi port serial card is automatically initiated upon the landing of the aircraft.

18. An aircraft data transmission system, the aircraft having an avionics system, comprising:

means for transmitting data from the avionics system via a cellular infrastructure after the aircraft has landed, wherein the transmission of the data is initiated automatically upon landing of the aircraft; and

means for receiving said data from said cellular infrastructure.

19. The aircraft data transmission system of claim 18, wherein said means for transmitting data includes a processor.

20. The aircraft data transmission system of claim 18, wherein said means for receiving data includes a processor.

21. A method of transmitting maintenance and diagnostic data from an aircraft, comprising:

at the aircraft,

receiving the maintenance and diagnostic data from a plurality line replaceable units;

transmitting the maintenance and diagnostic data via a cellular communications infrastructure after the aircraft has landed, wherein the cellular communications infrastructure is accessed automatically upon landing of the aircraft; and

at a data reception unit, receiving the transmitted maintenance and diagnostic data.

[redacted]

22. A method of transmitting maintenance and diagnostic data from an avionics system located on an aircraft, comprising:

receiving the maintenance and diagnostic data from a plurality of line replaceable units;

processing maintenance and diagnostic data; and

transmitting the processed maintenance and diagnostic data via a cellular infrastructure after the aircraft has landed, wherein the cellular infrastructure is accessed automatically upon landing of the aircraft.

23. The method of claim 22, further comprising receiving said transmitted data at a flight operations center.

24. The method of claim 22, further comprising receiving said transmitted data at a flight operations center via a computer network.

25. The method of claim 22, further comprising receiving said transmitted data at a flight operations center via a telephone network.

26. The method of claim 19, wherein processing said data includes:

compressing the data;

encrypting the data;

segmenting the data; and

constructing packets of data from said segmented data.

27. The method of claim 22, wherein receiving said transmitted data includes:

acknowledging receipt of said transmitted data;

reassembling said received data;

decrypting said reassembled data;

uncompressing said decrypted data; and

storing said uncompressed data.

28. A method of transmitting maintenance and diagnostic data from an aircraft, comprising:

receiving data from a plurality of line replaceable units;

processing the data; and

transmitting the processed data via a cellular infrastructure after the aircraft has landed, wherein processing said data includes:

[redacted]

receiving a signal which indicates that the data transmission process can begin;

initiating a data transfer;

compressing said data;

encrypting said compressed data;

creating a packet queue;

starting a primary data thread;

waiting a predetermined period of time;

determining if any threads are active;

repeating, when threads are active, the steps of waiting a predetermined period of time and determining if any threads are active; and

exiting processing said data when no threads are active.

29. The method of claim 28 wherein starting a primary data thread includes:

initiating a PPP connection;

initiating a transfer session;

starting at least one secondary data thread;

determining if data remains in the primary data thread;

sending said data when data remains in the primary data thread;

determining if data threads are active when no data remains in the primary data thread;

repeating, when said threads are active, the step of determining if data remains in the primary data thread;

ending said session when no threads are active;

closing said PPP connection; and

exiting starting a primary data thread.

30. The method of claim 29 wherein starting at least one secondary data thread includes:

(a) setting the secondary data thread to active;

(b) initiating a PPP connection;

(c) determining if data remains in the secondary data thread;

(d) sending a data packet when data remains;

(e) repeating step c when data remains;

(f) closing said PPP connection when no data remains;

(g) setting the secondary data thread to inactive;

(h) exiting starting at least one secondary data thread; and

(i) repeating steps a through h for each secondary data thread.

31. The method of claim 30, wherein repeating steps a through h includes repeating steps a through h in parallel for each said secondary data thread.

32. A computer-implemented method of transmitting maintenance and diagnostic data from an aircraft, comprising:

receiving the maintenance and diagnostic data from a plurality of line replaceable units;

processing the maintenance and diagnostic data; and

transmitting the processed data via a cellular infrastructure after the aircraft has landed; and

receiving the transmitted data at a flight operations center, wherein receiving said transmitted data includes:

creating a socket;

receiving a message;

determining if said message is an initialization message;

initiating a session when said message is an initialization message;

determining if said message is a data message when said message is not an initialization message;

processing said message when said message is a data message;

determining if said message is an end session when said message is not a data message;

processing said message when said message is an end session; and

repeating, when said message is not an end session message, the step of receiving a message.

33. The method of claim 32 wherein initiating a session includes:

allocating buffer space;

[redacted]

sending an initiation session acknowledgment; and

returning to receiving a message.

34. The method of claim 32, wherein processing said message when said message is a data message includes:

copying said message to a buffer;

sending a data message acknowledgment; and

returning to receiving a message.

35. The method of claim 32, wherein processing said message when said message is not an end session includes:

computing a checksum;

determining if said checksum is valid;

saving a buffer to a temporary file;

decrypting said temporary file;

uncompressing said temporary file;

sending an end session acknowledgment; and

returning to receiving a message.

36. An article of manufacture comprising a computer program carrier, readable by a processor and embodying one or more instructions executable by the processor to perform the method of transmitting maintenance and diagnostic data from an avionics system located on an aircraft, the method comprising:

receiving maintenance and diagnostic data from a plurality of line replaceable units;

processing said maintenance and diagnostic data to prepare said data for transmission; and

transmitting said processed data via a cellular infrastructure when said aircraft has landed, wherein the cellular infrastructure is accessed automatically upon landing of the aircraft.

[redacted]

ABSTRACT

The present invention resides in a system, method and an article of manufacture for transmitting maintenance and diagnostic data from an aircraft. The system comprises an aircraft, a cellular infrastructures and a data reception unit. The aircraft has an avionics system and a communications unit. The avionics system comprises a plurality of line replaceable units, and the communications unit is connected to each line replaceable, unit. The cellular infrastructure is in communication with said communications unit after the aircraft has landed. The communication is initiated automatically upon the landing of the aircraft. The data reception unit is connected to the cellular infrastructure.

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10272753 - 101207

Docket No.
21679-81051

Declaration For Patent Application

English Language Declaration

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTIC DATA DOWNLOAD TRANSMISSION SYSTEM

the specification of which

(check one)

☒ is attached hereto.

☐ was filed on _____ as United States Application No. or PCT International Application Number _____

and was amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d) or Section 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)			Priority Not Claimed
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐
_____ (Number)	_____ (Country)	_____ (Day/Month/Year Filed)	☐

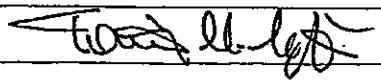
I hereby claim the benefit under 35 U.S.C. Section 119(e) of any United States provisional

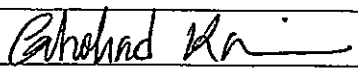
(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)
(Application Serial No.)	(Filing Date)

I hereby claim the benefit under 35 U. S. C. Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. Section 112, I acknowledge the duty to disclose to the United States Patent and Trademark Office all information known to me to be material to patentability as defined in Title 37, CFR Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)
(Application Serial No.)	(Filing Date)	(Status) (patented, pending, abandoned)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor **Tamas M. Igloi**
Sole or first inventor's signature  Date 10-9-02
Residence **4730 Cadison Street, Torrance, California 90503**
Citizenship **USA**
Post Office Address **Same as above**

Full name of second inventor, if any **Ghobad Karimi**
Second inventor's signature  Date 10/19/2002
Residence **19641 Anadale Drive, Tarzana, California 91356**
Citizenship **USA**
Post Office Address **Same as above**

Full name of third inventor, if any
Third inventor's signature Date
Residence
Citizenship
Post Office Address

Full name of fourth inventor, if any
Fourth inventor's signature Date
Residence
Citizenship
Post Office Address

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10272753.101702

Our Docket No. 21679-81051 PATENTS

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Tamas M. Igloi and Ghobad Karimi
Serial No.: Unassigned
Filed on: Herewith
Title: **AIRCRAFT AVIONICS MAINTENANCE DIAGNOSTIC DATA DOWNLOAD TRANSMISSION SYSTEM**

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Assistant Commissioner for Patents
Washington, D. C. 20231

Dear Sir or Madam:

The undersigned assignee of the entire interest in the above-identified patent application hereby appoints the following attorneys and/or agents:

Name	Registration No.
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Jeffrey A. Finn	51,679
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Michelle Kim	51,881
Denise L. McKenzie	43,790
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Samuel Tiu	47,997

all members of the bar of the State of California, whose address is SIDLEY AUSTIN BROWN & WOOD LLP, 555 West Fifth Street, Los Angeles, California 90013-1010, to prosecute and transact all business in the United States Patent and Trademark Office relating to this application.

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Respectfully submitted,

TELEDYNE TECHNOLOGIES INCORPORATED

Dated: 10/9/2002

Melanie S. Cibik, Esq.
Vice President and Assistant Secretary

LA1 457045v1

[redacted]

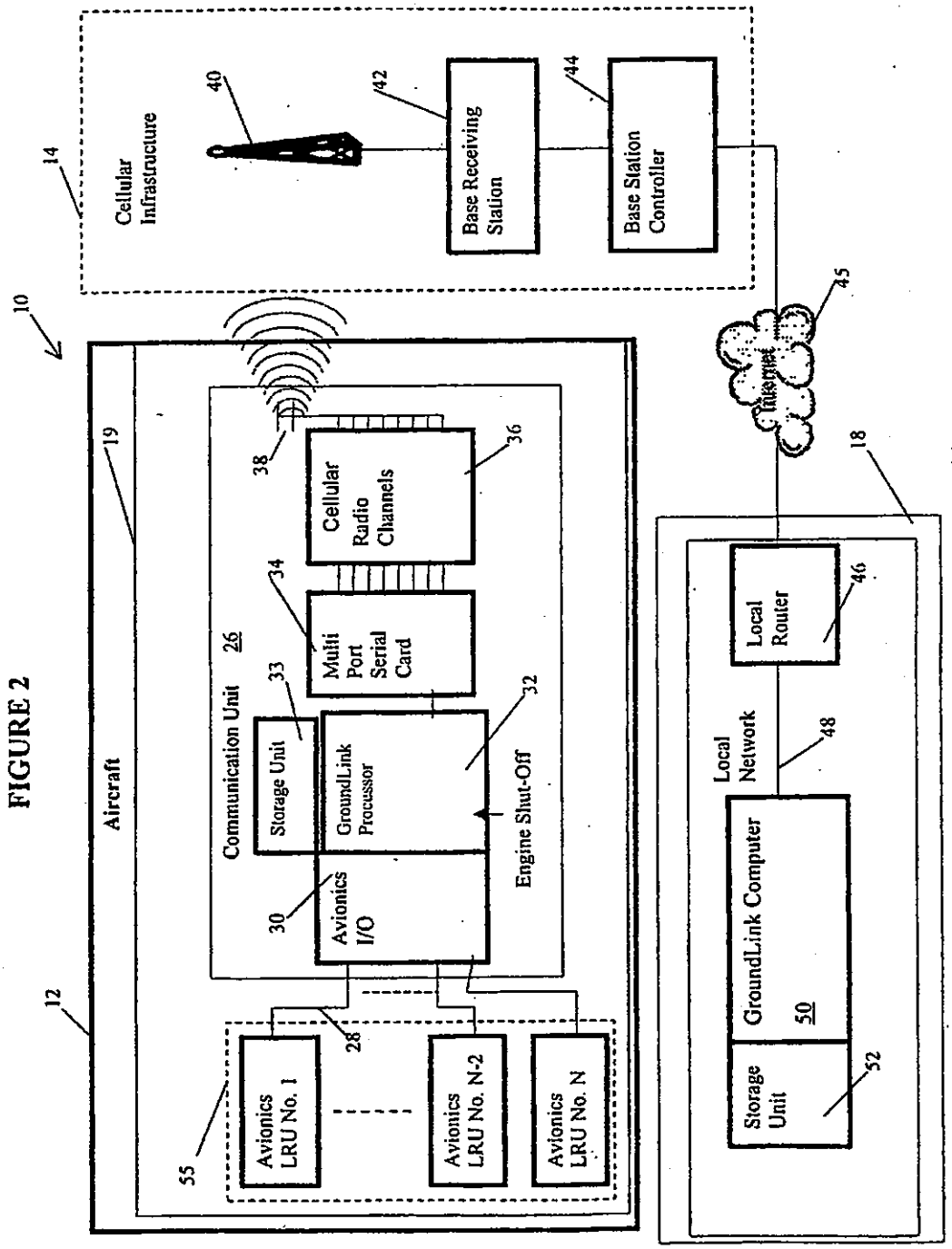

Cellular Infrastructure
14
40
42
Base Receiving Station
44
Base Station Controller
45
Internet
10
Aircraft
19
38
Cellular Radio Channels
36
34
Multi Port Serial Card
Communication Unit 26
33
Storage Unit
GroundLink Processor
32
Engine Shut-Off
30
Avionics I/O
12
28
55
Avionics LRU No. 1
Avionics LRU No. N-2
Avionics LRU No. N
18
Local Router
46
Local Network
48
GroundLink Computer
50
Storage Unit
52

FIGURE 2

Figure 3

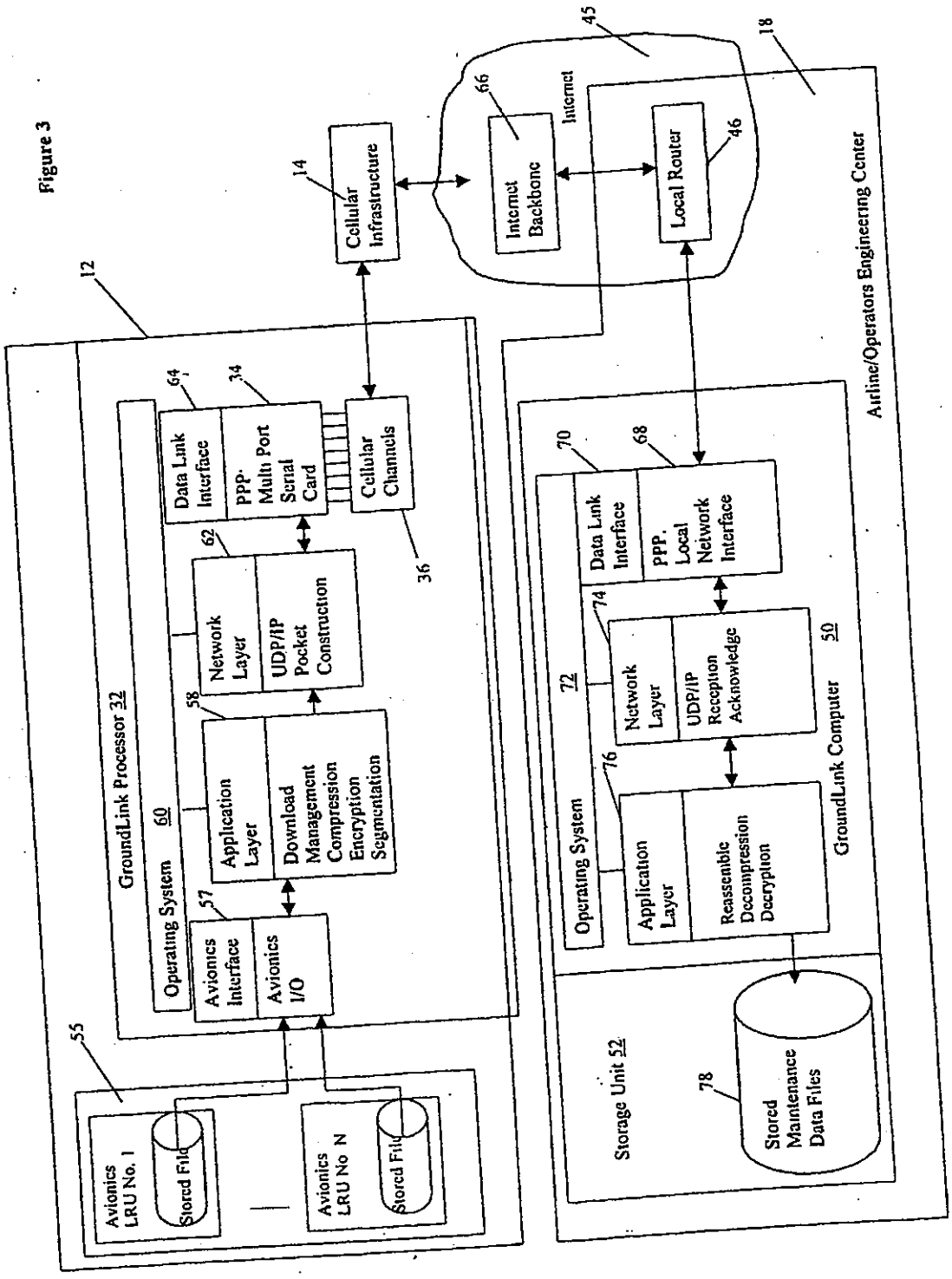

Airline/Operators Engineering Center
18
45
Internet
66
Internet Backbone
Local Router
46
Cellular Infrastructure
14
12
GroundLink Processor 32
Operating System 60
Data Link Interface
64
PPP. Multi Port Serial Card
34
Cellular Channels
36
Network Layer
62
UDP/IP Packet Construction
Application Layer
58
Download Management Compression Encryption Segmentation
Avionics Interface
57
Avionics I/O
55
Avionics LRU No. 1
Stored File
Avionics LRU No N
Stored File
Operating System 72
Data Link Interface
70
PPP. Local Network Interface
68
Network Layer
74
UDP/IP Reception Acknowledge
50
GroundLink Computer
Application Layer
76
Reassemble Decompression Decryption
Storage Unit 52
Stored Maintenance Data Files
78

FIGURE 4

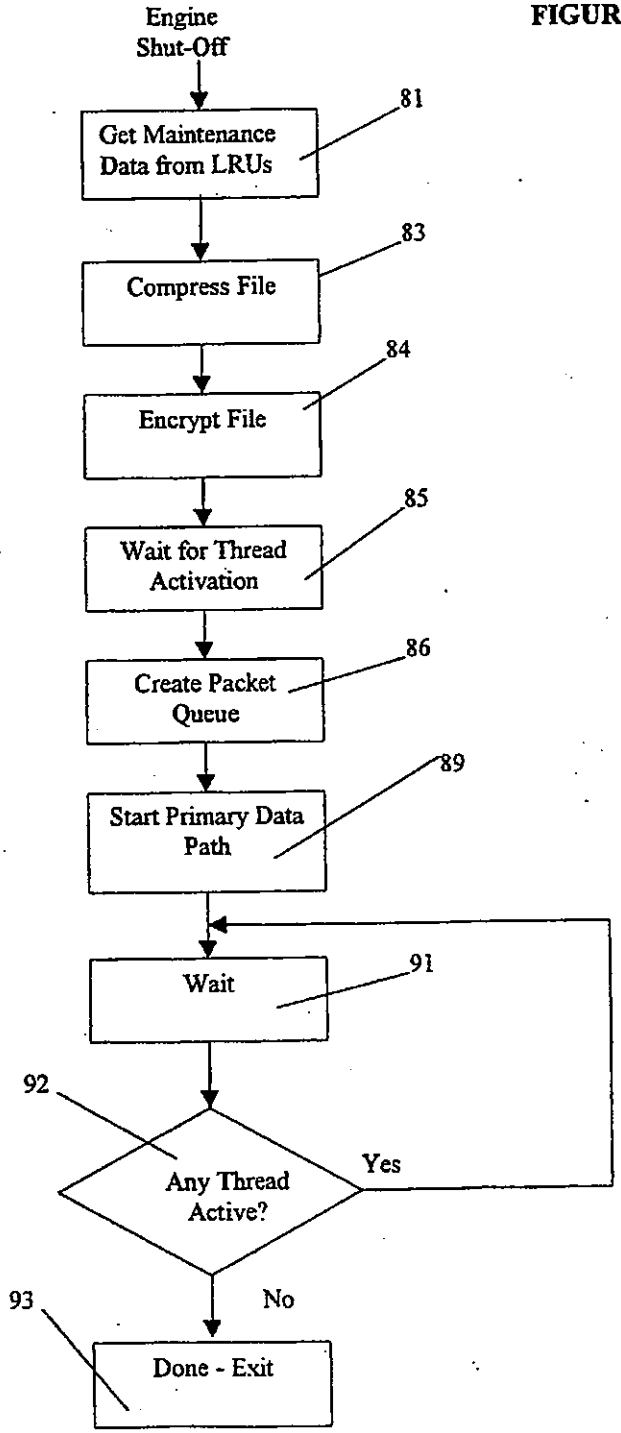
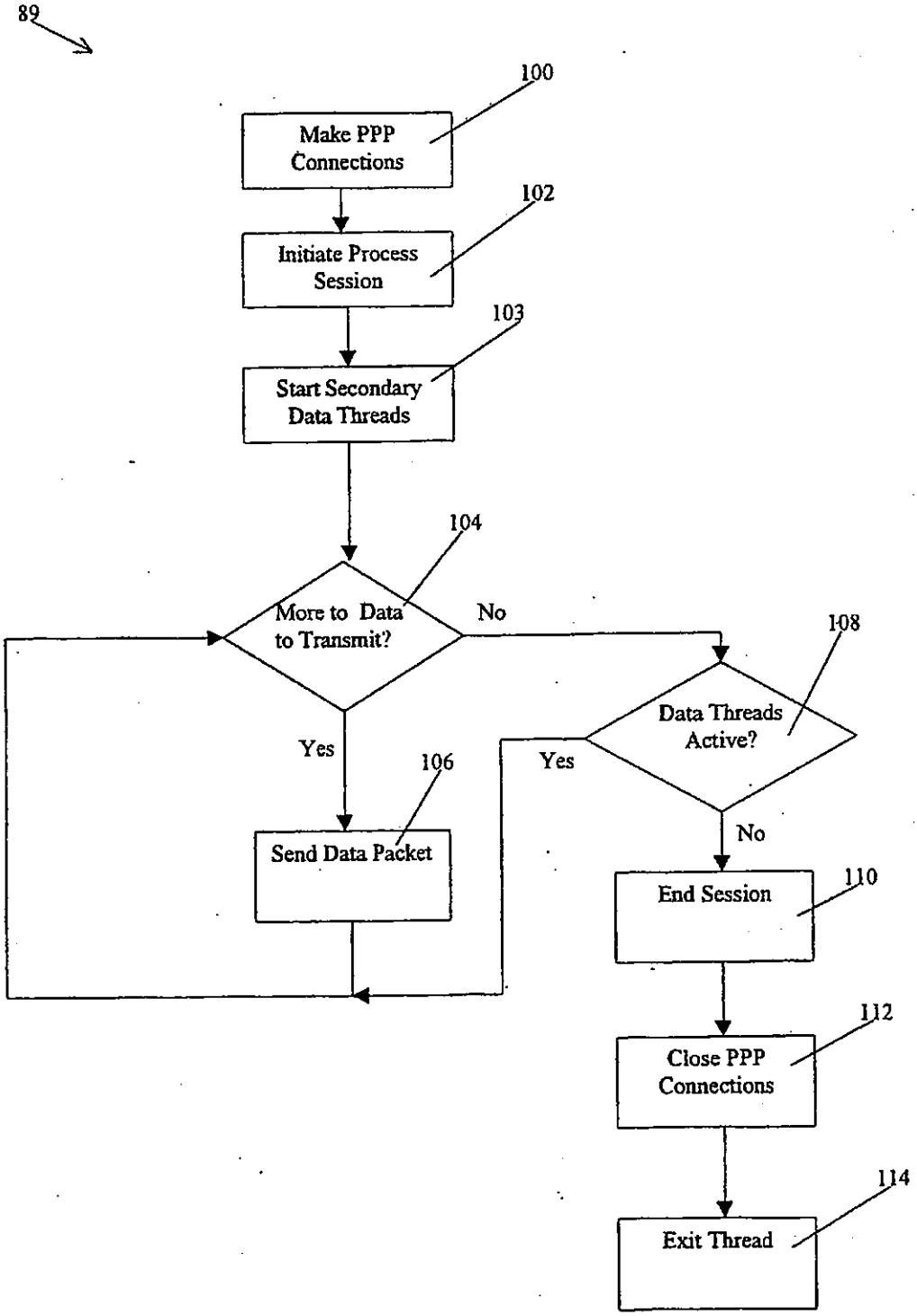

Engine Shut-Off
81
Get Maintenance Data from LRUs
83
Compress File
84
Encrypt File
85
Wait for Thread Activation
86
Create Packet Queue
89
Start Primary Data Path
91
Wait
92
Any Thread Active?
Yes
No
93
Done - Exit

FIGURE 5


89
100
Make PPP Connections
102
Initiate Process Session
103
Start Secondary Data Threads
104
More to Data to Transmit?
No
Yes
106
Send Data Packet
108
Data Threads Active?
Yes
No
110
End Session
112
Close PPP Connections
114
Exit Thread

ADC7153_001702

FIGURE 6

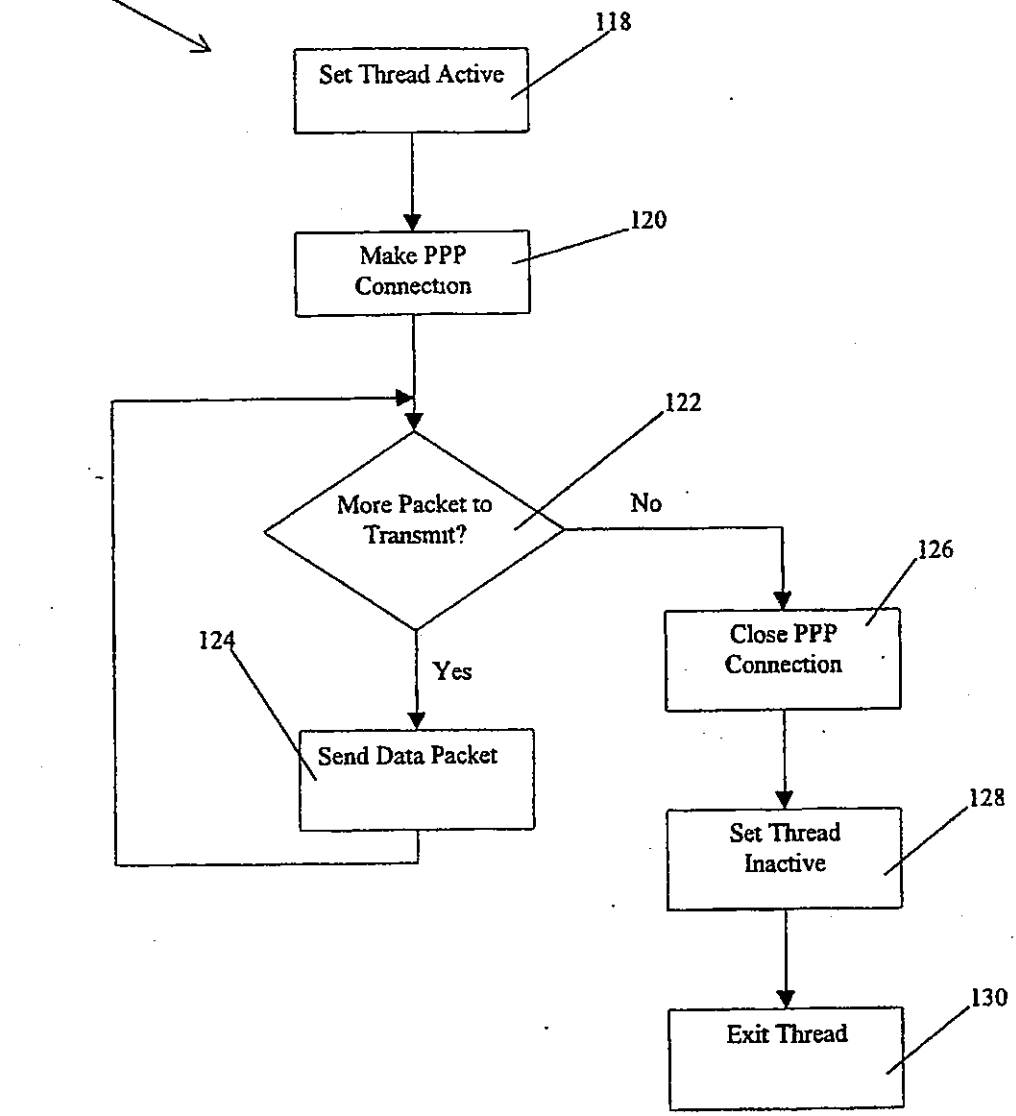


FIGURE 7

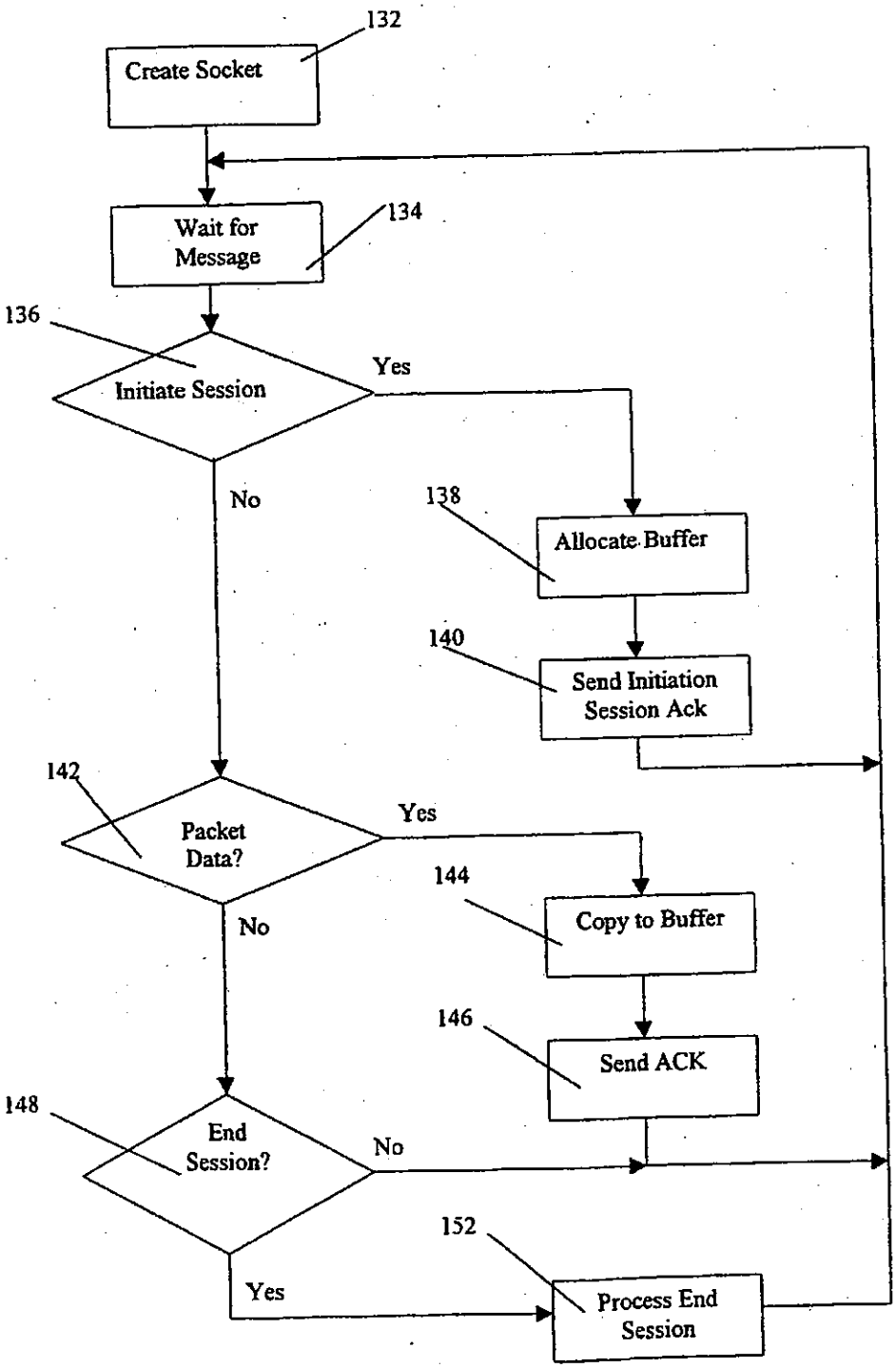
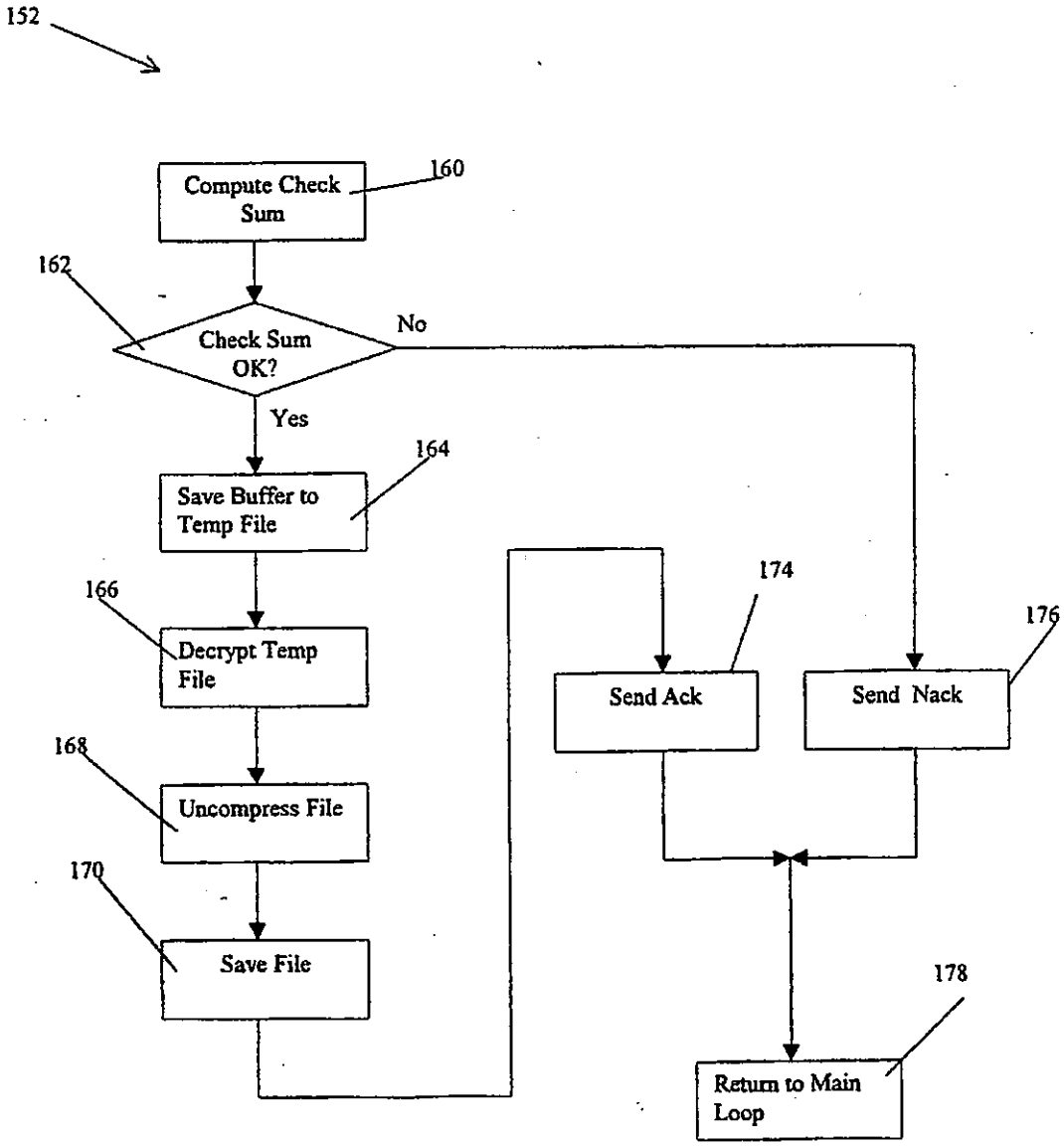
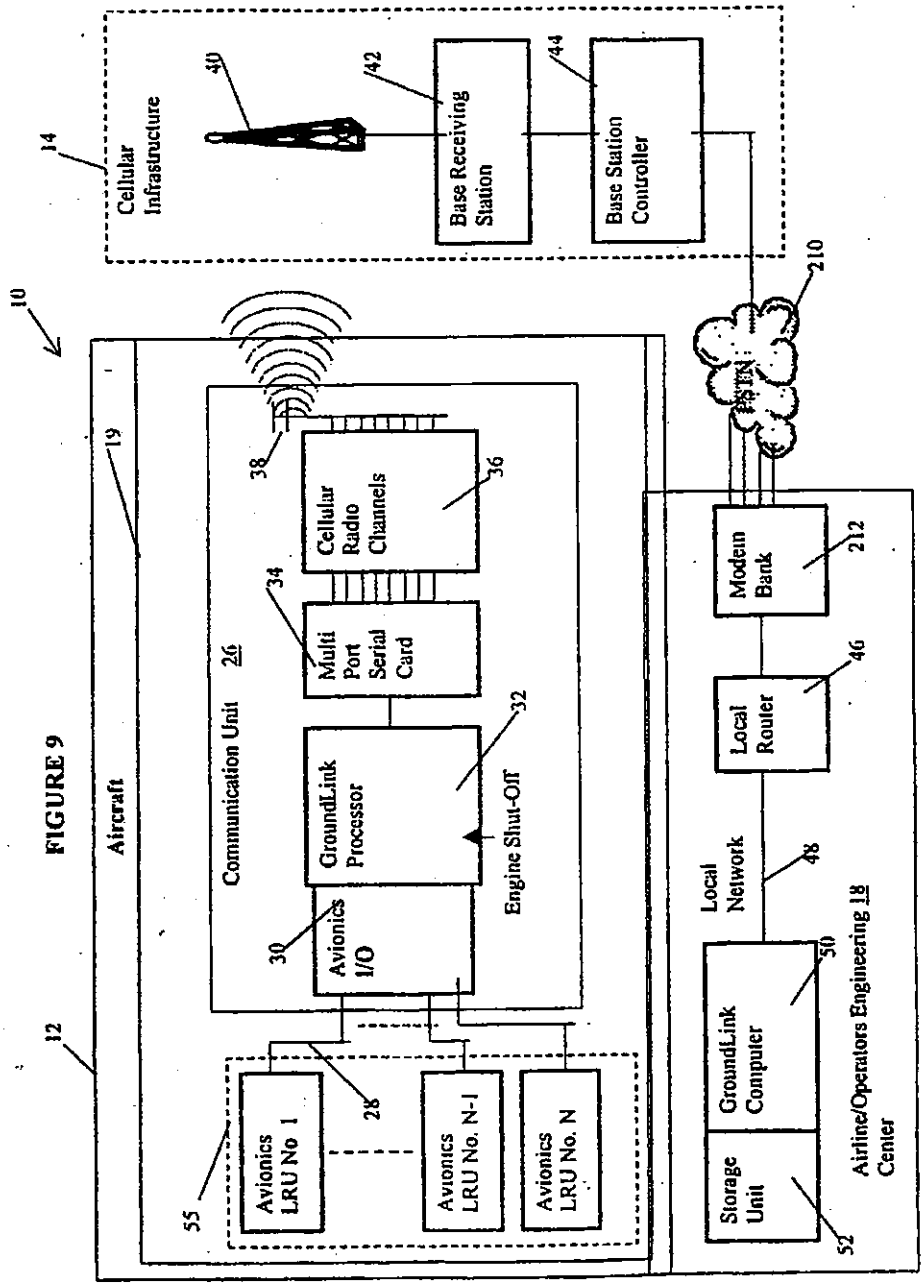

132
Create Socket
Wait for Message
134
136
Initiate Session
Yes
No
138
Allocate Buffer
140
Send Initiation Session Ack
142
Packet Data?
Yes
No
144
Copy to Buffer
146
Send ACK
148
End Session?
No
Yes
152
Process End Session

FIGURE 8


152
Compute Check Sum
160
162
Check Sum OK?
No
Yes
164
Save Buffer to Temp File
166
Decrypt Temp File
168
Uncompress File
170
Save File
174
Send Ack
176
Send Nack
178
Return to Main Loop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34
Multi Port Serial Card
Communication Unit 26
GroundLink Processor
32
Engine Shut-Off
30
Avionics I/O
12
28
55
Avionics LRU No 1
Avionics LRU No. N-1
Avionics LRU No. N
Aircraft
Modem Bank
212
Local Router
46
Local Network
48
GroundLink Computer
50
Storage Unit
52
Airline/Operators Engineering 18 Center

FIGURE 9